REMARKS

Summary of Amendments

Independent claims 1 through 3 have been amended to recite a special property—namely, a characteristically low sheet resistance—achieved in diamond produced according to the present invention as recited in these claims. This sheet resistance feature is supported by in claim 6 as filed, being recited as a limitation on the diamond set forth in the claim.

Claim 5 was canceled in Applicant's October 10, 2007 reply to the previous action by the Office.

New claims 7 through 9 have been added. These dependent claims are supported by Tables V and VIII, which respectively set forth results achieved by Embodiments 5 and 7. In particular, sample diamond Nos. 72 and 73 in Table V, and Nos. 86 and 87 in Table VIII were produced according to the parameters recited commonly in claims 7 and 8, achieving the *Li* and *N* concentration at the maximum depth where their implantation profiles overlap, and the sheet resistance, recited in claim 9.

Claims 1-4 and 6-9 are thus pending further consideration and examination by the Examiner.

Claim Rejections – 35 U.S.C. § 103

<u>Claims 1-4 and 6; Zaitsev (in view of routine skill in art)</u>

Claims 1-4 and 6 remain rejected as being unpatentable over *Optical Properties of Diamond: A Data Handbook* by A. M. Zaitsev, in view of alleged routine skill in the art.

The § 103 rejections in the current Office action are nearly a verbatim repetition of those in the previous action. The only difference is that claim 5 is, of course, not addressed, and that its limitations are incorporated *mutatis mutandis* into the recitations of the rejections—just as the claim 5 limitations were incorporated as amendments into the claims in Applicant's October 10, 2007 reply.

Following the restatement of the § 103 rejections, on page 8 the Office refutes several of Applicant's arguments in the remarks section of the first-action reply. Certain of these refutations are addressed below.

Applicant argued that *Zaitsev* is exclusively concerned with the optical, not electrical, properties of diamond, and the Office counters that the claims are not directed to electrical properties of diamond, such as would be important to diamond-based semiconductor devices. Claims 1 through 3 have each been revised to recite that

the recited steps produce diamond having "a sheet resistance of not greater than 10^7 Ω/□." Clearly now the claims *are* directed to an electrical property of diamond—regarding which *Zaitsev* is completely silent.

Applicant's October 10, 2007 reply added to independent claims 1-3 the limitation that the *Li*- and *N*-implanted diamond is annealed "at a temperature in the range of from 800°C to less than 1800°C, under high-pressure conditions of at least 3 GPa." In response, Office cites "page 265, lines 17 and 18" of *Zaitsev* to show a motivation to optimize diamond annealing parameters. *Zaitsev* does state, under the caption to Fig. 5.107, "The ***annealing*** behavior of the H3 center strongly depends on the type of diamond and irradiation conditions." (Emphasis in original.) But again, as was argued in the first-action reply,

> from *Zaitsev* one must conclude that a skilled person in the art would not know what to expect—in terms of effect on optical properties to begin with, let alone electrical properties—from the different conditions investigated by earlier researchers for sintering and annealing both polycrystalline and synthetic diamond.

In particular, nothing in *Zaitsev* discloses, teaches, or even suggests any relationship between diamond annealing conditions and sheet resistance (or resistivity), let alone any details as to how the annealing process could be conditioned to achieve a characteristically *lowered* sheet resistance.

The present invention, on the other hand, as set forth in claims 1-3 provides a method of manufacturing *n*-type semiconductor diamond, <u>whereby said diamond has a sheet resistance of not greater than 10^7 Ω/□</u>.

It should be noted that the "Continuation Sheet" appended to the advisory action quotes the present common amendment to independent claims 1-3 as, "wherein said diamond has a sheet resistance of not greater than 10^7 Ω/□." This quotation is inaccurate, however, in that the phrasing of the amendment actually begins with the term "where**<u>by</u>**," not "where**<u>in</u>**." While MPEP 2111.04 states that the interpretation of "whereby" and "wherein" clauses must be decided on a case-by-case basis, it is believed that the general rule in U.S. patent practice is that a "whereby" clause recites in explicit terms what is implicit or inherent from the claim recitations preceding the "whereby" clause, and thus is for clarity's sake—clarity that may be necessary to patentably distinguish the claim.

With regard to the Office's allegation that the sheet resistance property recited in claim 6 is merely a "matter of finding an optimum workable range for some chosen design requirement utilizing *Zaitsev*," Applicant argued in the October 10, 2007 reply,

> [T]he Office should demonstrate how sheet resistance is a "chosen design requirement" that would lead a person skilled in the art to

optimize some result-effective variable(s) according to *Zaitsev* to arrive at the present invention.

In response, the Office merely mentions that the claims are given their broadest reasonable interpretation, such that "it is clear that the sheet resistance can be different depending on the type of diamond used."

It is respectfully submitted that this counterargument is off base, in that it only partially addresses Applicant's argument: The Office's answer just means that even if the sheet resistance of *Zaitsev*'s *Li*- and *N*-implanted diamond does not meet the limitations of the Applicant's claims, then it is only because the diamond is different.

Applicant's argument against the rejection of claim 6 perhaps could have been better phrased, but it was twofold—and now supports the patentability of all of the claims over *Zaitsev*: One, the Office had not clearly shown how a skilled artisan seeking to improve sheet resistance in diamond would turn to *Zaitsev*; and two, even if the skilled artisan did so turn to *Zaitsev*, the Office had not clearly shown how that skilled artisan would arrive at the present invention from thus having consulted *Zaitsev*.

Applicant notes that what *Zaitsev* terms "*n*-type" diamond includes, as stated on page 418 of the reference, diamond having the resistivity of Type Ib diamond. Accordingly, the *n*-type diamond set forth in *Zaitsev* presumably has a high resistance. Under the present invention, although Type IIa diamond is employed in some embodiments, in others, Type Ib is, yet the unexpectedly low sheet resistance that is characteristic of the present invention is nonetheless achieved.

The present-invention method produces *n*-type semiconductor diamond that exhibits properties different from those of diamond manufactured according to any of the methods discussed or mentioned in *Zaitsev*. In particular, by heat-treating *Li*- and *N*-incorporating diamond under high-pressure conditions of at least 3 GPa at a temperature in the range of from 800°C to less than 1800°C, the present invention produces diamond having an unexpectedly low sheet resistance of not greater than 10^7 Ω/□.

As noted on pages 10 and 11 of the specification as filed, the methods of the present invention, as recited in the independent claims, bring about *Li* and *N* pairing, such that the *Li*–*N* pairs do not associate with vacancies but instead become electrically activated shallow donors. This unexpected pairing of *Li* and *N* dopant ions leads to the low sheet resistance that is a distinguishing feature of *n*-type diamond according the present invention.

In rejecting claim 4, on page 6 of its October 18, 2007 communication, the Office states, "*Zaitsev* also teaches that the implantation apparatus depends on the type of diamond used." But this is simply untrue; *Zaitsev* nowhere states any such thing,

although *Zaitsev* does, as noted above, mention that annealing behavior depends on the type of diamond and on the irradiation—i.e., implantation—conditions.

With regard to the subject matter of claim 4, lines 7-17 on page 11 of the specification state,

> Furthermore, in order to get the *Li* and *N* ions to pair efficiently, preferably an ion-implantation apparatus having two ion-beam lines and an electron-beam line is utilized to implant the *Li* and *N* ions simultaneously while radiating with the electron beam the single-crystal diamond on which ion implantation is carried out. The inventors discovered that due to ion implantation, an atomic-level phenomenon in which implanted ions lose their energy while colliding with carbon atoms within the diamond crystal occurs at identical times with *Li* and with *N*, and that the supplying of electrons by the electron beam to the crystal surface of the single-crystal diamond on which ion implantation is carried out makes it so that *Li* and *N* distribute in locations within the single-crystal diamond in which pairing is likely to occur.

It is respectfully submitted that nothing in *Zaitsev* discloses, teaches, or even suggests this particular form of ion implantation, implemented in Embodiment 4 of the present invention, leading to the unexpected result—that is, to the discovery—of an enhanced effectiveness in the *Li* and *N* pairing that is unique to the present invention.

Accordingly, Applicant courteously urges that this application is in condition for allowance. Reconsideration and withdrawal of the rejections is requested. Favorable action by the Examiner at an early date is solicited.

Respectfully submitted,

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